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ADDED VALUE OF COMBINING MULTIPLE OPTICAL AND ACOUSTIC INSTRUMENTS WHEN CHARACTERIZING FINE-GRAINED ESTUARINE SUSPENSIONS

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ABSTRACT

Various optical and acoustic instruments have specific advantages and limitations for characterizing suspensions, and when used together more information can be obtained than with one instrument alone. The LISST 100K, for example, is a powerful tool for estimating particle size distribution, but because of the inversion method used to determine the size distribution, it is difficult to distinguish two dominant populations that peak close to one another, especially among large grain sizes. In the York River estuary, VA, additional information obtained through the deployment of a RIPScam camera system and an ADV along with the LISST 100K allowed differentiation between populations of resilient pellets and fines in suspension close to the bed and how the populations varied over a tidal cycle. A second example of instrument pairing providing additional information was the use of a PTW video imaging system in the York River to verify the conditions under which use of the ADV Reynolds flux method was valid for estimating sediment velocity of suspended particle populations.

MOTIVATION

Identify the contribution of multiple particle types to the suspended distribution and thus to the effective settling velocity (Wv as measured by the ADV)

STUDY SITE

- Clay Bank area on York River Estuary
- A micro-bath (1.7 to 1.2 meter) tributary of the Chesapeake Bay, VA
- In secondary channel at 7.5 meter depth
- (Site of long-term, 2007-2009, Observing System)

REFERENCES


CONCLUSIONS

- Using multiple instruments with various capabilities provides a more complete picture of the particle size distribution and their associated settling velocities.
- Both LISST and ADV in study 1 do a reasonable job of describing the mean effective Wv when U=20 cm/s. All observer suspended sediment suspension is insufficient to provide valid estimates of ADV when the modified Reynolds flux method is used.
- ADVs, however, provide long-term continuous estimates of Wv when it is impossible to deploy other instruments (for example during episodic events).
- LISST overestimates the mean or effective Wv because it is limited by pixel resolution. ADVs are likely biased towards particles that are larger and denser and thus produce stronger acoustic backscatter.
- Combination of the LISST, which is better at resolving smaller particles, and the RIPScam, which is better at resolving larger particles, does a reasonable job in describing the total suspension. However neither of these instruments are capable of direct measurement of Wv.
- Addition of LISST to PTW can help resolve contribution of the smaller particles particularly in the low stress periods.

METHOD--STUDY 1

6 Hour Study Period bracket Flood (Oct 6, 2012)

RESULTS

- Reduction of sediment concentration (Figure 3B) by 50% resulted in less than 1% change in ADV-based estimates of Wv (using modified Reynolds flux equations).
- Modified Reynolds flux method (ADV) for estimating mean Wv was noisier than PTW settings column observation (Figure 3A).
- Observed mean settling velocities (0.81±0.02 mm/ sec) were consistent with ADV-based estimates for cases with U<20 cm/s (0.81±0.04 mm/sec).
- Observed mean settling velocities were not consistent with ADV-based estimates for cases with U>20 cm/s
- For U=20 cm/s (0.81±0.04 mm/sec), ADV provides appropriate settling flux balance for ADV Wv calculation (Figure 3A)

METHOD--STUDY 2

25 Hour Study Period (July 28-29, 2009)

RESULTS

Example Distributions

- Low Stress Period (Figure 6A-B): LISST D50 and peak with RIPScam D16 suggest dominant fine size of ~315 µm
- LISST 2.5 µm indicates essentially no smaller fines in suspension
- RIPScam D50 shows a single large particle (whose size is better described by RIPScam peak = 1245 µm)
- Advanced stress period (Figure 6C-D): Larger LISST distributions suggest multiple particle types in suspension.
- LISST D50 and peak with RIPScam D16 suggest dominant particle size in suspension is ~315 µm (resilient pellets).
- LISST D50, RIPScam D50 and peak suggest a second particle size of ~200 µm (flux of size reduced by turbulence)

Verification

INSTRUMENTS to measure Settling Velocity (Ws) As measured by:

Acoustic Doppler Velocimeter (ADV)

Advantages:
- Non-invasive single point velocity measurement
- Less susceptible to bio-fouling and can be used in higher concentration ranges than optical instruments
- Burst data used to estimate effective settling velocity (Ws), as well as flux, turbulence, stress, and concentration when calibrated
- Simple deployment and data processing

Disadvantages:
- Can not track individual or groups of particles - only valid for effective (buoy) Ws.
- Profiler must be stationary - profiler motion interferes with velocity calculations.

INSTRUMENTS to measure Particle Size Distribution As measured by:

Laser In Situ Scattering Transmissometer (LISST 100K)

Measurement Range: 0.5 to 500 µm

Advantages:
- Good resolution of smaller particle sizes (21 of 52 logarithmically spaced size classes <=100 µm)
- Simple deployment and data processing
- Can be deployed autonomously

Disadvantages:
- Highly susceptible to bio-fouling when deployed autonomously
- Can be used in high concentration regimes
- Poor resolution of large particles and limited range

Impedance TCI Cam (RIPScam)

Measurement range: >300 µm

Advantages:
- Highly susceptible to bio-fouling when deployed autonomously
- Can capture large particles
- Can be used in high concentration regimes
- Data processing time intensive
- Can not be used in high concentration regimes

Clarification

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Background photo provided by Kelley A. Fall. Particles collected on a 63 micron sieve from sediment trap deployed on Clay Bank tripod Aug-Aug 2013. Total sediment captured in trap was composed of 98.4% mud (98.7% clay, 20.7% silt) with 7.8% of this mud fraction packaged as resilient pellets.